BIOLOGICAL SURVEYS OF SANTA MONICA BAY ARTIFICIAL REEF and TOPANGA ARTIFICIAL REEF

by **Dennis Bedford, Jerry Kashiwada** *and* **Greg Walls**

Marine Resources Division
Administrative Report 96-3
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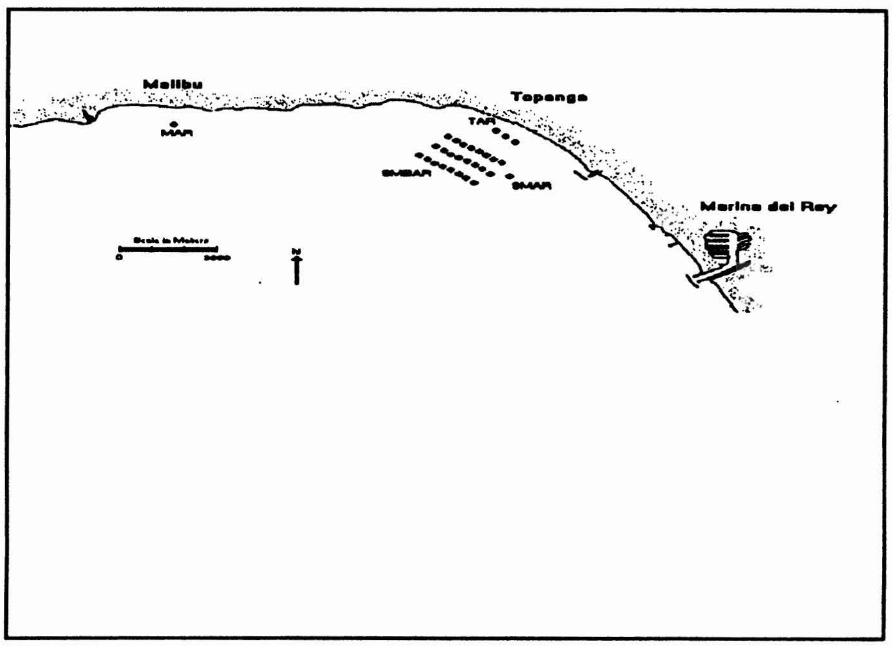

Figure 1 MAR - Malibu Artificial Reef; SMBAR - Santa Monica Bay Artificial Reef; SMAR - Santa Monica Artificial Reef.

Introduction

This report details the development of the biological communities on 2 artificial reefs off southern California (Figure 1). Santa Monica Bay Artificial Reef (SMBAR) and Topanga Artificial Reef (TAR) were both constructed in 1987 with 20,000 and 10,000 tons of quarry rock respectively.

SMBAR was constructed in the manner of replication reefs which were designed by researchers to study the effects of environmental and structural variables on reef productivity *in situ* and TAR was built to promote kelp habitat. SMBAR is composed of 24 module pairs of varying height and rock size arranged along three depth strata while TAR was built in 3 piles along one depth strata (Table 1, Figure 2 & Figure 3).

SMBAR is located at 34° 00' 47"N; 118° 32' 33" W approximately 5 nautical miles from the Marina del Rey entrance along a course of 290° magnetic. TAR is located at 34° 01' 38.10" N; 118° 31' 54.80" W; approximately 5.25 nautical miles from the Marina del Rey entrance along a course of 302° magnetic.

The modules of SMBAR cover 3.58 acres of the 256 acres allotted in the permit. Each module has a footprint of about 0.07 acres. The modules of TAR cover 2 acres of 13 acres allotted in the permit. Each module has a footprint of about 0.70 acres.

During the late fall of 1995 both reefs were surveyed by Department divers to assess how closely their biological communities had progressed towards a stable "equilibrium" community. Due to the relatively young age of the reefs and the rapid successional change which occurs in the associated biotic communities of new reefs (Carlisle *et al.* 1964; Turner *et al.* 1969; Carter *et al.* 1985; Matthews 1985; Solonsky 1985; Ambrose and Swarbrick 1989; Anderson *et al.* 1989; Hueckel and Buckley 1989; and Wilson *et al.* 1990), only qualitative surveys were conducted.

Methods

In November 1995, Nearshore Sport Fish Habitat Enhancement Program (NSHEP) biologist-divers surveyed both reefs to evaluate the assemblage of fishes, macroinvertebrates, turf communities (small sessile invertebrates and plants), and macroalgae on selected modules at each depth contour. Modules were located by using the Geographic Positioning System (GPS), and a fathometer.

Relative abundances of fishes were estimated while swimming over and around a module several times. These estimates were placed into four categories: abundant (>50 individuals), common (11-50 individuals), occasional (2-11 individuals), and one (1 individual). Fish size was estimated using three categories: adult (A), juvenile (J), and young-of-year (YOY).

A distinction is made between both invertebrates and algae which are large or rare enough that individuals can be counted and those whose numbers are so great that they blanket large areas of a reef. There is no clear biological distinction between these groupings, but as a matter of convenience the former are labeled macroinvertebrates and macroalgae, while the latter are categorized as the "turf" community. This categorization greatly eases our task of estimating species abundance.

Densities of macroinvertebrates and macroalgae were estimated by counting all individuals, within one meter on either side of a transect line, run from the base of a module over the crest and down to the base on the opposite side. The counts are reported as the average number of individuals per square meter (m^2). In addition to actual counts, macroalgae size was estimated using three categories of height: A1 (1 in.- 1 ft.), A2 (1 ft. to the subsurface), and A3 (surface canopy).

Estimated percent cover for turf community organisms was averaged for twelve quarter square meter quadrats placed at uniform intervals along one side of the transect line described above. Organisms were identified and assigned to taxa (taxonomic groups). Percent coverage for each taxa was estimated for each quadrat and averaged for the module. Taxa were later categorized as abundant (>50% cover), common (11-50% cover), occasional (2-11% cover), or rare (≤1% cover).

Physical data collected included module depth, height and water visibility. Module depth and height were determined by averaging numerous depth gauge readings taken along the module base and crest (surface), respectively.

Results

Physical Data

SMBAR 18 was surveyed on 28 November 1995. Visibility was >30 feet, module height was 14 feet, and depth was 72 feet (Table 1). SMBAR 10 was surveyed on 29 November 1995. Visibility was 25 feet, module height was 14 feet, and depth was 57 feet. SMBAR 3 was surveyed on 29 November 1995. Visibility was 15 feet, module height was 13 feet and depth was 42 feet.

The western Topanga module was surveyed on 30 November 1995. Visibility was <5 feet, module height was 7 feet and depth was 28 feet.

Biological Data (Biotic Communities)

Fishes

Many of the fish species common on nearshore reefs in southern California (Lewis *et al.* 1989) were observed on each of the modules surveyed (Table 2). Blacksmith (*Chromis punctipinnis*) was the most numerous at all modules. Adult, juvenile, and young-of-year blacksmith were observed in abundant numbers at all modules. The only other fish observed in abundant numbers was the señorita wrasse (*Oxyjulis californica*). Adult, juvenile, and YOY señorita wrasse were abundant at TAR and common at SMBAR 10. Popular sport fish species such as kelp bass (*Paralabrax clathratus*), barred sand bass (*Paralabrax nebulifer*), California sheephead (*Semicossyphus pulcher*), and sculpin (*Scorpaena guttata*) were common or occasional on all modules. A variety of other species were also found at the artificial reefs (Tables 2).

The deep module, SMBAR 18, had the fewest species, 12, of the modules surveyed. Nine species were observed in 1993 (Bedford *et al.* 1994), 10 in 1990 (Grant 1991), and 5 in 1989 (Lewis *et al.* 1989). One fish species, blacksmith, was present as adult, sub adult and YOY forms and 11 were only present as adults.

SMBAR 10, the middle module, had the greatest number of species, 18. In 1993 13 species were observed (Bedford *et al.* 1994), 15 in 1992 (Bedford and Tarpley, 1992), 10 in 1990 (Grant, 1991), and 8 in 1989 (Lewis *et al.* 1989). Twelve species were present only in adult forms, 4 as adult and sub adults, and 2 as adults, sub adults and YOY.

Sixteen species were found at SMBAR 3, the shallowest of the SMBAR modules surveyed. Eleven were observed in 1993 (Bedford *et al.* 1994), 13 in 1990 (Grant 1991), and 14 in 1989 (Lewis *et al.* 1989). Eleven species were present only in adult forms, 4 as adult and sub adults, and 1 as adult, sub adult and YOY.

The second fewest species, 13, were found on TAR, which was the shallowest module, lowest relief, and most importantly, had the worst visibility. Eighteen species were found in 1993 (Bedford *et al.* 1994) and 14 in 1989 (Lewis *et al.* 1989). Ten species were present in adult forms only, 2 as adult and sub adults, and 1 as adult, sub adult, and YOY.

Macroinvertebrates

The number of macroinvertebrate species observed at the reefs ranged from 4 to 7 per module (Tables 3). Four macroinvertebrate species were found at SMBAR 18 with rock scallops, *Hinnites* sp., being the most common. Three species were found in 1993 (Bedford *et al.* 1994), 3 in 1990 (Grant 1991), and 1 in 1989 (Lewis *et al.* 1989) (Table 3).

The mid-depth module at SMBAR 10 had 5 macroinvertebrate species. Rock scallops were the most common species. Four species were found in 1993 (Bedford *et al.* 1994), 6 in 1992 (Bedford and Tarpley

1992), 3 in 1990 (Grant 1991), and 1 in 1989 (Lewis *et al.* 1989) (Table 3).

SMBAR 3 had 7, the most macro-invertebrate species of all the modules surveyed. Rock scallops were the most common species. Seven species were found in 1993 (Bedford *et al.* 1994), 5 in 1990 (Grant 1991), and 2 in 1989 (Lewis *et al.* 1989) (Table 3).

The western TAR module had 4 macroinvertebrate species. Purple sea urchins (*Stronglyocentrotus purpuratus*) were the most common species present. Four species were found in 1993 (Bedford *et al.* 1994), and 7 in 1989 (Lewis *et al.* 1989) (Table 3).

Turf Community

Invertebrate turf communities on these reef modules generally show an increase in number of taxa and percent coverage from the 1993 survey (Table 4). SMBAR 18 (deep module) had 10 taxa on both surveys. SMBAR 10 (middle module) increased from 12 taxa to 15 and SMBAR 3 (shallow module) increased from 11 taxa to 13. TAR also increased from 8 taxa in 1993 to 10 in 1995. Some taxa such the ostrich plume hydroid, *Aglaophenia struthionides*, were either lower in abundance or not sampled in the current survey. Other taxa such as gorgonians, *Muricea* sp., increased in abundance or were sampled for the first time this year.

Total percent coverage of invertebrate turf for SMBAR 10, SMBAR 18, and TAR increased while a dramatic decrease was seen on SMBAR 3 (Table 4). This decrease at SMBAR3 was due to a much lower abundance of mussels, *Mytilus* sp. Erect ectoprocts and scaled worm mollusks, *Serpulorbis squamigerus*, were the most abundant turf invertebrates except for SMBAR 18 where scaled worm mollusks were relatively rare. Increases in gorgonian percent coverage are notable since these species are dominant organisms on the older artficial reefs off Torrey Pines and Camp Pendleton.

Although algal turf has increased over the years, there was no consistent trend for each module compared to the 1993 survey (Table 5). Total algal turf coverage dropped on the shallower modules (SMBAR 3 and TAR) and increased on the deeper modules (SMBAR 10 and 18). Variations in percent coverage are mainly related to changes in abundance of foliose red algae (Table 5).

Macroalgae

Giant kelp, *Macrocystis pyrifera*, and other macroalgae were not found at SMBAR or TAR in 1995. Macroalgae were found in 1993, 1990, and 1989 with giant kelp surface canopies in 1989 on the shallow SMBAR modules and at TAR (Table 6).

Discussion

Since surveys made before 1993 used imprecise navigational instrumentation that could not determine which modules were being sampled, comparisons between early surveys must assume all modules at a given depth are undergoing similar patterns of community development. Some of the changes noted could have been the result of differing development patterns on the surveyed modules. The accuracy of GPS technology eliminates this source of variation by enabling us to reliably return to the same modules. The same three module pairs were sampled at SMBAR in 1993 and 1995. A different module at TAR was sampled in 1995 because of poorer water clarity at the module sampled in 1993.

The number of fish species on SMBAR and TAR are generally within the range of 10-19 found in previous surveys of southern California artificial reefs (Ambrose and Swarbrick, 1989). Not only has the number of species at each module increased over time, but fish community diversity has also increased. SMBAR 10, for example, had 8 fish species in 1989. Four were classified as abundant, 3 were occasional and one was observed as an individual. SMBAR 10 had 18 species in 1995. Only one was classified as abundant, 9 were common, 7 were occasional and one was observed as a lone individual. Thus, over time, the number of numerically dominant species is decreasing as the diversity increases.

The number of size categories among species present is also increasing. In 1990, juveniles of only 2 species, blacksmith and sheephead, were observed at SMBAR 3. Other species present were classified as adults. Blacksmith were the only juveniles at SMBAR 10 and SMBAR 18. By 1993, as many as 6 species were observed as adults and juveniles on SMBAR 10. Six species also had adults and juveniles on SMBAR 10 in 1995. Initially the reef attracted transient, mostly adult fish. Now SMBAR provides habitat for fish that were recruited to the site as YOY creating a more diverse mix of sizes.

Species abundance has also changed since 1989 at SMBAR and TAR. Blacksmith were classified as occasional in 1989 at both reefs (Table 2). By 1990 blacksmith numbers increased into the abundant range. By 1995 each module had very large schools of blacksmith. Blacksmith are obligate reef users (Bray 1981) and have continued to prosper at the reefs.

Other resident species including the rock wrasse (*Halichoeres semicinctus*), garibaldi (*Hypsypops rubicundus*) and the señorita have gone from one or less in 1989 to ocassional or more in 1995 at SMBAR and TAR.

Despite the increased diversity at SMBAR and TAR, some fish species have not faired as well. The olive rockfish (*Sebastes serranoides*) at SMBAR 10 for example has gone from abundant in 1990 to occasional in 1992 and 1993 to completely absent in 1995. Loss of kelp may be a contributing factor to the olive rockfish's current absence (Turner *et al.* 1969). Sculpin were abundant in 1989 and 1990 on most of the SMBAR modules, common in 1993 and occasional in 1995. White surfperch (*Phanerodon furcatus*) were abundant on all modules in 1989 and have fluctuated between common and absent in subsequent surveys. Turner *et al.* (1969) saw similar fluctuations in abundance and believed this species was not strongly associated with rocky habitat.

Other species including the kelp bass, barred sand bass, sculpin, black eye goby (*Coryphopterus nicholsii*) and bluebanded goby (*Lythrypnus dalli*) have been observed each year. Still others such as the relatively rare finescale triggerfish (*Balistes polylepis*) have made recent appearances on the reef. The composition of fish species continues to evolve.

YOY sheephead and rock wrasse were not

observed at SMBAR or TAR even though they were seen during this time at Santa Monica Artificial Reef (SMAR) which is less than 0.5 miles from SMBAR 3. SMAR was built 26 years prior to TAR and SMBAR and has a larger, more mature gorgonian population which may offer protective cover to YOY sheephead and rock wrasse. This added cover may increase survivorship of sheephead and rock wrasse recruits making them more common on SMAR than either TAR or SMBAR.

The minimal (<5 foot) visibility at TAR was a possible reason that the number of fish observed in 1995 was less than in 1993 when the visibility was 10 feet. Fish may have simply stayed beyond our field of vision. The present lack of macroalgae on TAR is another contributing factor (Quast 1968) (Heck & Orth 1980). Hard bottom with kelp seems to hold more fish than hard bottom without kelp.

Macroinvertebrate abundance and diversity has also increased over time. When these surveys began in 1989, divers combed the entire reef counting organisms. Transect counts were used to subsample the modules after 1992 because it became impractical to count all the macroinvertebrates on the reef.

SMBAR 10 demonstrates a typical increase in macroinvertebrate abundance. In 1989 only one species, the spiny lobster (*Panulirus interruptus*), was observed. In 1995 five species, including lobsters were observed. Macroinvertebrates like the giant keyhole limpet (*Megathura cremulata*) become more common as the reef community matures. For example, only one giant keyhole limpet was seen at the Pendleton Artificial Reef during the 5 years after the reef was constructed and none were seen during the first 3 years of the replication reef studies in Santa Monica Bay.
In 1995 the density of giant keyhole limpets at the shallow module of SMBAR was 20 times greater than in 1993. Giant keyhole limpets were observed for the first time at TAR and SMBAR 10 during the 1995 survey (Table 3).

Unlike fish and macroinvertebrate communities, macroalgae abundance has not steadily increased over time. SMBAR 3 and TAR had giant kelp surface canopies in 1989, 2 years after the reefs were created. Not only did the canopy disappear after 1990, but no macroalgae of any kind were observed along transects in 1995.

Giant kelp has become established on artificial reefs of various designs for a few years after construction and then vanish. Everything from auto body reefs at Paradise Cove in the 1950s to the quarry rock of Carlsbad Artificial Reef in the 1990s has recruited kelp only to lose it after several years. SMBAR and TAR appear to be additional examples of this pattern.

Most artificial reefs have several common factors that may inhibit development of persistent kelp beds. Compared to natural kelp beds most artificial reefs are small, are located far from natural beds, and are of relatively high profile. Large, low profile artificial reefs near existing kelp beds may promote more persistent kelp beds.

The turf communities at SMBAR and TAR are still undergoing changes in species composition and overall abundance. These changes are consistant with turf communities studied at Torrey Pines Artificial Reef (TPAR) and Pendleton Artificial Reef (PAR) (Palmer-Zwahlen and Aseltine, 1994). Community development on SMBAR and TAR was similar to PAR (Palmer-Zwahlen and Aseltine, 1994). Species which were early dominants such as mud ectoprocts and hydroids have been replaced by dominants such as erect ectoprocts and gorgonians.

Comparisons of current and past turf community surveys at these reefs are difficult since early surveys were more qualitative than quantitative and methods differed. Never the less, there has been a general increase in number of invertebrate taxa over the years. The longer taxa list for TAR in 1989 is probably the result of different sampling methods, but could also be due to sampling different modules. Because the earlier study covered large areas of the reef, rare taxa were more likely to be found and counted than in later studies in which only taxa found in quadrats were counted.

In conclusion, the biological communities at SMBAR and TAR continue to develop within expected patterns. Private and charter vessels can be seen fishing at the reefs on any given day. Young fish and invertebrates are recruiting to the reefs while older cohorts reside, feed, and seek shelter on the reefs. The algal and invertebrate turf communities are also increasing in diversity and maturity.

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Table 1. Physical Data for Santa Monica Bay and Topanga Artificial Reefs

Module	Module Depth (feet)	Module Height (feet)	Visibility (feet)	Latitude North	Longitude West	Remarks
SMBAR 3	42	13	15	34° 01' 02.06"	118° 32' 09.78"	east module
SMBAR 10	57	14	25	34° 00' 36.05"	118° 32' 02.18"	east module
SMBAR 18	72	14	>30	34° 00' 17.84"	118° 32' 13.30"	east module
TAR	28	7	<5	34° 01' 38.10"	118° 31' 54.80"	west module

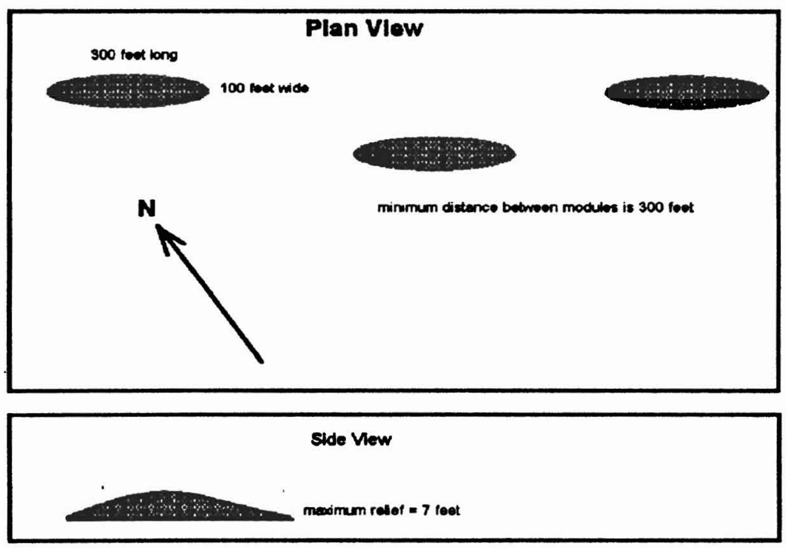

Figure 2: Topanga Artificial Reef design

Table 2. FISH SPECIES RELATIVE ABUNDANCE

1989		1990		1992		1993		1995	
SHALLOW MODULE									
barred sandbass	A	blacksmith	A			blacksmith	A	blacksmith	A
black eye goby	A	sculpin	A			barred sand bass	C	barred sand bass	C
white surfperch	A	barred sand bass	C			kelp bass	C	black croaker	C
kelp bass	C	black croaker	C			pile surfperch	C	black surfperch	C
sculpin	C	black perch	C			white surfperch	C	halfmoon	C
black croaker	O	kelp bass	C			black croaker	O	kelp bass	C
black surfperch	O	sargo	C			black surfperch	O	pile surfperch	C
blacksmith	O	black eye goby	O			halmoon	O	rubberlip surfperch	C
giant kelpfish	O	blue banded goby	O			rock wrasse	O	sargo	C
pile perch	O	brown rockfish	O			sargo	O	sheephead	C
cabezon	1	halfmoon	O			sheephead	O	fine scale trigger fish	O
halibut	1	sheephead	O					opaleye	O
rock wrasse	1	giant kelp fish	1					rock wrasse	O
rockfish unident.	1							sculpin	O
								white surfperch	O
								brown rockfish	1
MIDDLE MODULE									
barred sand bass	A	barred sand bass	A	barred sandbass	A	blacksmith	A	blacksmith	A
black eye goby	A	blacksmith	A	blackeye goby	A	señorita	A	barred sand bass	C
sculpin	A	olive rockfish	A	blacksmith	A	barred sand bass	C	black croaker	C
white surfperch	A	sculpin	A	rubberlip surfperch	C	kelp bass	C	black surfperch	C
blacksmith	O	black eye goby	C	black surfperch	O	pile perch	C	kelp bass	C
kelp bass	O	kelp bass	C	kelp bass	O	rubberlip perch	C	pile surfperch	C
pile surfperch	O	sheephead	C	olive rockfish	O	sculpin	C	rock wrasse	C
black surfperch	1	black surfperch	O	pile surfperch	O	olive rockfish	O	señorita	C
		pile surfperch	O	rainbow surfperch	O	painted greenling	O	sheephead	C
		brown rockfish	1	rock wrasse	O	sheephead	O	white surfperch	C
				sheephead	O	bluebanded goby	1	black eye goby	O
				white perch	O	black croaker	1	bluebanded goby	O
				black croaker	1	brown rockfish	1	halfmoon	O
				bluebanded goby	1			opaleye	O
				sculpin	1			rainbow surfperch	O
								rubberlip surfperch	O
								sculpin	O
								curlfin turbot	1
DEEP MODULE									
barred sand bass	A	blacksmith	A			blacksmith	A	blacksmith	A
sculpin	A	sculpin	A			barred sand bass	C	barred sand bass	C
white surfperch	A	barred sand bass	C			kelp bass	C	black eye goby	C
black eye goby	O	black eye goby	C			pile surfperch	C	kelp bass	C
blacksmith	O	black surfperch	C			sculpin	C	sheephead	C
		kelp bass	C			black eye goby	O	black surfperch	O
		pile surfperch	C			sheephead	O	bluebanded goby	O
		cabezon	O			cabezon	1	pile surfperch	O
		halfmoon	O			rubberlip perch	1	rock wrasse	O
		sheephead	O					rubberlip surfperch	O
								sculpin	O
								black croaker	1
TOPANGA									
white surfperch	A					blacksmith	A	blacksmith	A
barred sand bass	C					black perch	C	señorita	A
kelp bass	C					olive rockfish	C	barred sand bass	C
pile surfperch	C					señorita	C	black surfperch	C
black croaker	O					barred sand bass	O	black croaker	O
black eye goby	O					brown rockfish	O	garibaldi	O
black surfperch	O					halfmoon	O	halfmoon	O
blacksmith	O					kelp bass	O	kelp bass	O
rock wrasse	O					rainbow surfperch	O	pile surfperch	O
sculpin	O					rubberlip surfperch	O	rock wrasse	O
top smelt	O					white surfperch	O	white surfperch	O
halibut	1					black seabass	1	brown rockfish	1
rock wrasse	1					fine scale trigger fish	1	white croaker	1
rockfish unident.	1					garibaldi	1		
						opaleye	1		
						rock wrasse	1		
						sargo	1		
						sculpin	1		

A=abundant (>50); C=common (11 to 50); O=occasional (2 to 10); 1 = one

Table 3. **MACROINVERTEBRATE RELATIVE ABUNDANCE**

1989		1990		1992				1995	
SHALLOW MODULE					density (#/m²)		density (#/m²)		density (#/m²)
lobster	O	crab	C			purple urchin	0.15	rock scallop	1.33
sheepcrab	1	purple urchin	C			rock scallops	0.07	purple urchin	0.39
		rock scallop	C			short spined star	0.03	giant spined star	0.33
		giant spined star	O			giant keyhole limpet	0.02	giant keyhole limpet	0.28
		lobster	O			lobster	0.02	red urchin	0.11
						sea cucumber	0.02	star unidentified	0.11
						whelk	0.02	lobster	present
MID MODULE									
lobster	O	lobster	C	rock scallops	1.67	rock scallops	0.27	rock scallop	3.00
		nudibranch	O	whelk	0.16	purple urchin	0.1	giant spined star	0.12
		rock scallop	O	purple urchin	0.10	whelk	0.03	purple urchin	0.12
				red urchin	0.02	red urchin	0.02	triton	0.06
				short spined star	0.02			lobster	present
				leafy hornmouth	present				
DEEP MODULE									
lobster	O	rock scallop	C			rock scallop	0.28	rock scallop	3.00
		crab	O			lobster	0.03	giant keyhole limpet	0.21
		lobster	O			whelk	0.02	whelk	0.10
								lobster	0.05
TOPANGA									
lobster	O					purple urchin	1.13	purple urchin	2.19
sheepcrab	O					red urchin	0.2	red urchin	0.47
snail	O					rock scallop	0.07	giant keyhole limpet	0.06
giant spined star	O					whelk	0.03	lobster	0.02
crab	1								
urchin unidentified	1								
6 rayed star	1								

A=abundant (>50); C=common (11 to 50); O=occasional (2 to 10); 1 = one
Prior to 1992 total counts were used to describe macro invertebrate abundance.
Transects were used to describe density begining in 1992.
Present indicates that the organism was present on the module, but not recorded on transects.

Table 4. **TURF INVERTEBRATE RELATIVE ABUNDANCE**

1989		1990		1992		1993		1995	
SHALLOW MODULE					%cover		% cover		% cover
mud ectoproct	A	ostrich plume hydroid	C			mussels	87.4	erect ectoproct	19.6
hydroid	A	abalone jingle	C			erect ectoproct	27.5	scaled worm mollusk	15.3
barnacle	A	bryzoan	C			hydroid	10.1	hydroid	10.4
tube worms	C	barnacle	C			ostrich plume hydroid	9.4	golden gorgonian	6.0
tunicate	C	mussel	C			strawberry anemone	3.0	red gorgonian	5.0
bryozoan	O	hydroid	C			feather duster worm	2.6	strawberry anemone	5.0
feather duster worm	O	feather duster worm	O			scaled worm mollusk	1.5	encrusting sponge	4.7
stalked tunicate	O	scaled worm mollusk	O			tunicate	1.5	feather duster worm	3.4
strawberry anemone	R					striped acorn barnacle	1.4	mussel	3.0
ostrich plume hydroid	1					golden gorgonian	1.2	encrusting ectoproct	1.8
						barnacle	1.0	orange cup coral	1.5
								striped acorn barnacle	1.0
								Chama sp.	7.0/m²
MIDDLE MODULE									
mud ectoproct	A	barnacle	A	ostrich plume hydroid	28.8	erect ectoproct	32.0	erect ectoproct	29.2
hydroid	A	mud ectoproct	A	hydroid	21.3	ostrich plume hydroid	14.1	scaled worm mollusk	17.8
barnacle	A	abalone jingle	C	erect ectoproct	13.4	encrusting sponge	10.5	strawberry anemone	9.0
strawberry anemone	R	strawberry anemone	C	barnacles	12.1	hydroid	10.0	ostrich plume hydroid	8.0
		bryzoan	O	strawberry anemone	5.0	strawberry anemone	7.0	hydroid	7.3
		feather duster worm	O	sponges	2.5	scaled worm mollusk	2.0	red gorgonian	6.0
		hydroid	O	encrusting ectoproct	2.1	barnacle	1.2	encrusting sponge	4.4
		ostrich plume hydroid	O	tunicate	0.4	gorgonian	1.0	golden gorgonian	3.3
				scaled worm mollusk	0.4	stalked tunicate	1.0	encrusting ectoproct	2.0
				gold gorgonian	present	mussel	1.0	striped acorn barnacle	1.7
				red gorgonian	present	sponge	1.0	brown cup coral	1.0
						Chama sp.	6.3/ m²	brown gorgonian	1.0
								feather duster worm	1.0
								tunicate	1.0
								Chama sp.	7.0/m²
DEEP MODULE									
mud ectoproct	A	mud ectoproct	A			erect ectoproct	26.7	erect ectoproct	34.2
hydroid	A	bryzoan	C			ostrich plume hydroid	5.0	encrusting sponge	8.6
barnacle	A	encrusting sponge	O			hydroid	5.0	hydroid	7.9
encrusting ectoproct	C	ostrich plume hydroid	O			scaled worm mollusk	1.5	scaled worm mollusk	2.6
bryzoan	O					sponge	1.5	encrusting ectoproct	2.3
strawberry anemone	R					barnacle	1.0	ostrich plume hydroid	2.0
						boring clam	1.0	strawberry anemone	2.0
						feather duster worm	1.0	striped acorn barnacle	1.3
						stalked tunicate	1.0	orange cup coral	1.0
						Chama sp.	1.8/m²	*Chama sp.*	8.7/m²
TOPANGA									
mud ectoproct	A					erect ectoproct	36.7	scaled worm mollusk	58.8
bryzoan	A					scaled worm mollusk	25.0	erect ectoproct	27.7
hydroid	A					encrusting sponge	10.0	gold gorgonian	11.5
ostrich plume hydroid	A					hydroid	2.5	hydroid	7.8
barnacle	A					ostrich plume hydroid	2.0	encrustng sponge	4.7
boring clam	A					cup coral	1.0	feather duster worm	2.0
stalked tunicate	A					feather duster worm	1.0	parchment tube worm	2.0
tube worms	A					parchment tube worm	1.0	encrusting ectoproct	1.4
feather duster worm	C							three winged murex	1.0
tunicate	C							*Chama sp.*	0.7/m²
mussel	O								
encrusting ectoproct	R								

Abundance estimates for turf invertebrates before 1992: A=abundant (>50% cover); C=common (11-50% cover; O=occasional (2 -11% cover); R=rare (<1% cover).
Abundance estimates for 1992 and later years are expressed in percentages.

Table 5. TURF ALGAE RELATIVE ABUNDANCE

1989		1990		1992		1993		1995	
SHALLOW MODULE					%cover		% cover		% cover
Foliose Red Algae		**Foliose Red Algae**				**Total Foliose Red Algae**	22.7	**Total Foliose Red Algae**	4.3
Callophyllis	O	*Gigartina*	C			other foliose reds	20.0	foliose reds	4.3
Gigartina	O	*Callophyllis*	O			*Rhodymenia*	2.7		
Polyneura	O	*Polyneura*	O						
Nienbergia	R	*Rhodymenia*	R						
Rhodymenia	R								
Filamentous Red Algae	none	**Filamentous Red Algae**	none			**Filamentous Red Algae**	14.4	**Filamentous Red Algae**	17.1
Foliose Brown Algae		**Foliose Brown Algae**				**Total Foliose Brown Algae**	2.4	**Total Foliose Brown Algae**	3.3
algal turf	C	*Pachydictyon*	O			*Pachydictyon*	2.4	*Pachydictyon*	3.3
Pachydictyon	R								
Filamentous Brown Algae	none	**Filamentous Brown Algae**	none			**Filamentous Brown Algae**	none	**Filamentous Brown Algae**	none
MIDDLE MODULE									
Foliose Red Algae		**Foliose Red Algae**		**Total Foliose Red Algae**	11.8	**Total Foliose Red Algae**	6.2	**Total Foliose Red Algae**	16.2
Callophyllis	R	*Gigartina*	O	*Rhodymenia*	11.8	*Rhodymenia*	6.2	other foliose reds	8.2
Gigartina	R	*Rhodymenia*	O					*Rhodymenia*	8.0
Polyneura	R	*Callophyllis*	R						
Nienbergia	R	*Polyneura*	R						
Rhodymenia	R								
Filamentous Red Algae	none	**Filamentous Red Algae**	none	**Filamentous Red Algae**	20.8	**Filamentous Red Algae**	none	**Filamentous Red Algae**	8.6
Foliose Brown Algae		**Foliose Brown Algae**	none	**Total Foliose Brown Algae**	1.3	**Foliose Brown Algae**	none	**Foliose Brown Algae**	none
algal turf	O			*Pachydictyon*	1.3				
DEEP MODULE									
Foliose Red Algae		**Foliose Red Algae**				**Total Foliose Red Algae**	15.8	**Total Foliose Red Algae**	40.9
Gigartina	R	*Gigartina*	R			*Rhodymenia*	7.0	*Callophyllis*	2.0
Polyneura	R	*Polyneura*	R			*Gigartina*	5.8	*Gigartina*	11.1
Rhodymenia	R	*Rhodymenia*	R			*Callophylis*	3.0	*Rhodymenia*	14.2
								other foliose reds	13.6
Filamentous Red Algae	none	**Filamentous Red Algae**	none			**Filamentous Red Algae**	none	**Filamentous Red Algae**	5.0
Foliose Brown Algae	none	**Foliose Brown Algae**	none			**Foliose Brown Algae**	none	**Total Foliose Brown Algae**	5.0
								Desmarestia	5.0
TOPANGA									
Foliose Red Algae						**Total Foliose Red Algae**	73.2	**Total Foliose Red Algae**	38.2
Callophyllis	C					*Acrosorium*	28.8	*Acrosorium*	18.3
Gigartina	C					*Rhodymenia*	28.0	*Rhodymenia*	11.0
Polyneura	C					*Nienburgia*	10.0	foliose reds	7.2
Nienbergia	O					*Gigartina*	6.4	*Gigartina*	1.7
Rhodymenia	R								
Priontis	R								
Filamentous Red Algae	none					**Filamentous Red Algae**	none	**Filamentous Red Algae**	1.3
Foliose Brown Algae	none					**Foliose Brown Algae**	none	**Foliose Brown Algae**	none

Abundance estimates for turf algae before 1992: A=abundant (>50% cover); C=common (11-50% cover; O=occasional (2 -11% cover); R=rare (<1% cover).

Abundance estimates for 1992 and later years are expressed in percentages.